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Discovery of previously unrecognised local faults in London, UK, using detailed 3D geological modelling

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In parts of London, faulting introduces lateral heterogeneity to the local ground conditions, especially where construction works intercept the Palaeogene Lambeth Group. This brings difficulties to the compilation of a ground model that is fully consistent with the ground investigation data, and so to the design and construction of engineering works. However, because bedrock in the London area is rather uniform at outcrop, and is widely covered by Quaternary deposits, few faults are shown on the geological maps of the area.

This paper discusses a successful resolution of this problem at a site in east central London, where tunnels for a new underground railway station are planned. A 3D geological model was used to provide an understanding of the local geological structure, in faulted Lambeth Group strata, that had not been possible by other commonly-used methods. This model includes seven previously unrecognised faults, with downthrows ranging from about 1 m to about 12 m.

The model was constructed in the GSI3D geological modelling software using about 145 borehole records, including many legacy records, in an area of 850 m by 500 m. The basis of a GSI3D 3D geological model is a network of 2D cross-sections drawn by a geologist, generally connecting borehole positions (where the borehole records define the level of the geological units that are present), and outcrop and subcrop lines for those units (where shown by a geological map). When the lines tracing the base of each geological unit within the intersecting cross-sections are complete and mutually consistent, the software is used to generate TIN surfaces between those lines, so creating a 3D geological model.

Even where a geological model is constructed as if no faults were present, changes in apparent dip between two data points within a single cross-section can indicate that a fault is present in that segment of the cross-section. If displacements of similar size with the same polarity are found in a series of adjacent cross-sections, the presence of a fault can be substantiated. If it is assumed that the fault is planar and vertical, then the pairs of constraining data points in each cross-section form a two-dimensional envelope within which the surface trace of the fault must lie.

Generally, the broader the area of the model, the longer the envelope defined by the pairs of boreholes is, resulting in better constraint of the fault zone width and azimuth. Repetition or omission of the local stratigraphy in the constraining boreholes can demonstrate reverse or normal dip-slip motion. Even if this is not possible, borehole intercepts at the base of the youngest bedrock unit or at the top of the oldest bedrock unit can constrain the minimum angle of dip of the fault plane. Assessment of the maximum angle of dip requires intrusive investigation.